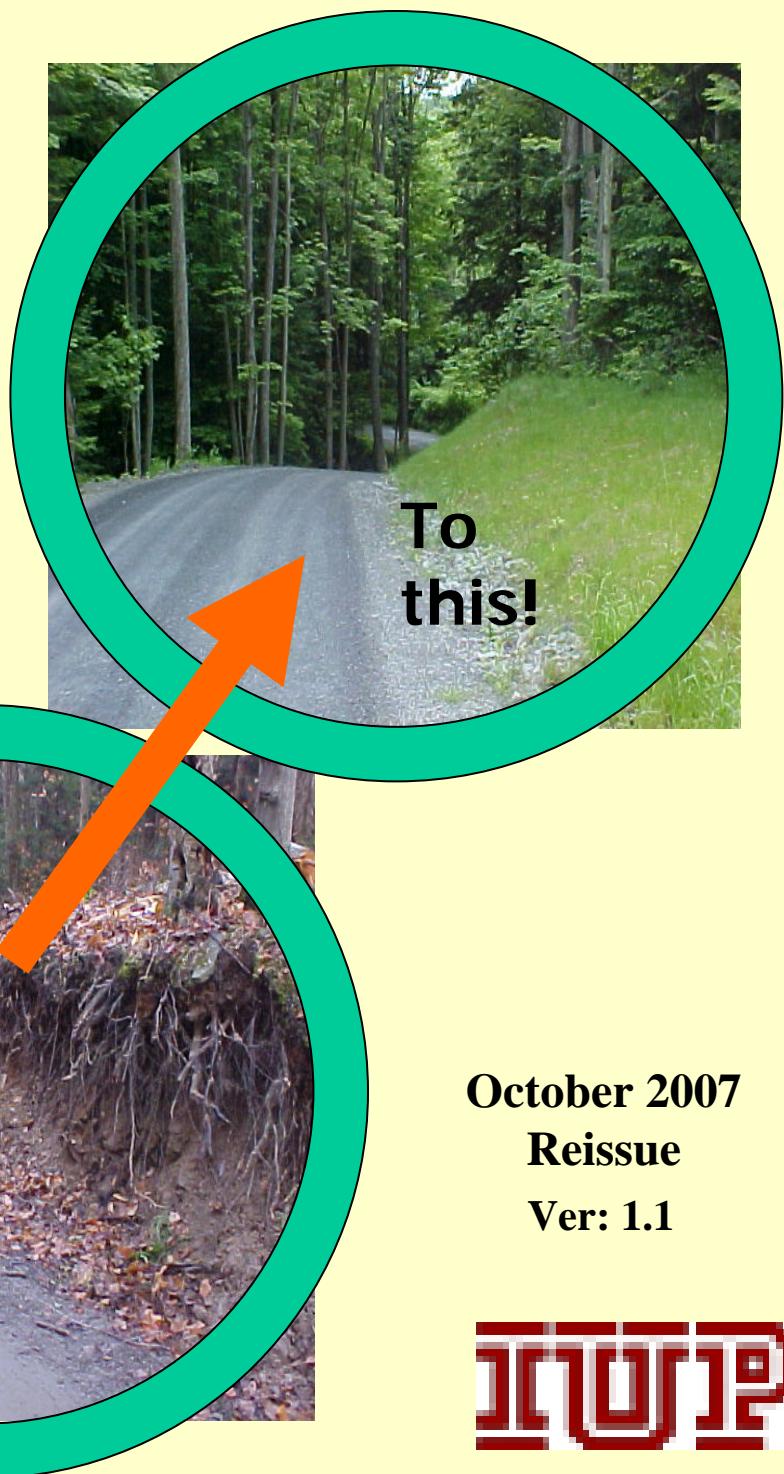
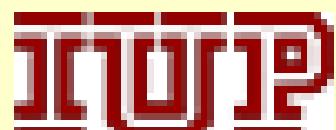


Environmentally Sensitive Maintenance for Dirt and Gravel Roads

- Better Roads
- Better Environment
- Better Community
- Less Maintenance



October 2007
Reissue
Ver: 1.1



NOTICE

This publication was developed under Assistance Agreement No. CP-83043501-0 awarded by the U.S. Environmental Protection Agency. It has not been formally reviewed by EPA. The views expressed in this document are solely those of the authors and EPA does not endorse any products or commercial services mentioned in this publication.

Technical Report Documentation Page

1. Report No. USEPA-PA-2005-	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Environmentally Sensitive Maintenance for Dirt and Gravel Roads		5. Report Date February 2006
		6. Performing Organization Code
7. Compiled by: Alan L. Gesford, P.E. and John A. Anderson, Ph.D.		8. Performing Organization Report No.
9. Performing Organizations Name and Address Administration & Leadership Studies – Research & Training Center Indiana University of Pennsylvania Dixon University Center, South Hall 2986 North Second Street Harrisburg, PA 17110		10. Work Unit No. (TRAIS)
		11. Grant Assistance I.D. No. CP-83043501-0
12. Sponsoring Agency Name and Address Commonwealth of Pennsylvania The Pennsylvania Department of Transportation Bureau of Maintenance and Operations Commonwealth Keystone Building 400 North Street, 6 th Floor Harrisburg, PA 17120-0064		13. Type of Report and Period Covered Technical Reference Manual
		14. Sponsoring Agency Code
15. Supplementary Notes Funding Assistance provided by the U. S. Environmental Protection agency		
16. Abstract This is a nonpoint source pollution project that identifies, documents, and encourages the use of environmentally sensitive maintenance of dirt and gravel roads. Specifically, this project involved the development of a reference manual and related technical information sheets on <i>Environmentally Sensitive Maintenance of Dirt and Gravel Roads</i> for national use. The manual will provide insight into using natural systems and innovative technologies to reduce erosion, sediment and dust pollution while more effectively and efficiently maintaining dirt and gravel roads. The manual will address the environment of forests, mountainous terrain, and rolling hills. Various states already employ some of the more common practices, particularly forestry departments. These states and their local governments are prime targets for deploying the additional practices to be addressed in the manual. The manual will give the users a ‘tool box’ full of environmentally sensitive maintenance ‘tools’ or practices, recognizing that not one tool can fit every situation or site or solve all their problems in maintaining their dirt and gravel roads and protecting the environment.		
17. Key Words Unpaved road maintenance Dirt and gravel roads maintenance Environmentally sensitive maintenance		18. Distribution Statement No Restrictions
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages
		22. Price

Environmentally Sensitive Maintenance For Dirt and Gravel Roads

**A Manual to provide guidance
using natural systems and innovative technologies to reduce erosion,
sediment and dust pollution while more effectively and efficiently
maintaining dirt and gravel roads.**

Compiled by
John A. Anderson, Ph.D.
Alan L. Gesford, P.E.

**Sponsored by the
Pennsylvania Department of Transportation**



**with Funding Assistance from the
U.S. Environmental Protection Agency**



This manual is based on information and training products developed by

Pennsylvania State Conservation Commission



& the Penn State Center for Study of Dirt & Gravel Roads



December, 2007

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views of either the Pennsylvania Department of Transportation or the U. S. Environmental Protection Agency. This report does not constitute a standard, specification, or regulation.

Acknowledgements:

Funding for the compilation of this manual was supplied under Grant Assistance I.D. No. CP-83043501-0 sponsored jointly by the U.S. EPA and PennDOT.

We would like to recognize Rod Frederick, Robert Goo, and Chris Solloway from the US EPA for their support, reviews and encouragement throughout the manual development. Our appreciation also goes to the Pennsylvania Department of Transportation, especially to Bob Peda, Bureau of Maintenance and Operations, who initially championed this manual project in cooperation with the US EPA.

Major Manual Contributors:

This manual has resulted from the initial two-year effort at the Pennsylvania Transportation Institute at Penn State and the Dirt and Gravel Roads Task Force, funded through the State Conservation Commission, which assemble materials for a 2-day ESM training program. Under the direction of the Center for Dirt and Gravel Road Studies, the training program has subsequently followed a path of continued quality improvements over the next seven years which has resulted in two comprehensive revisions to the original document. This manual owes its success to the contributions provided by:

John Anderson, IUP
Steve Bloser, CD&GS/PSU
Woodrow Cobert, SCC [retired]
Dave Creamer, CD&GS/PSU
Alan, Gesford, PSU
Dave Shearer, CD&GS/PSU

The re-issue of this manual has been done to provide formal recognition to the **Center for Dirt and Gravel Road Studies**, which is part of the Penn State Institutes of Energy and the Environment at The Pennsylvania State University, for their major contributions to the continued development of the ESM practices and training materials from the onset of the Center in 1999 to the present. It is the Center's activities and ongoing Environmentally Sensitive Maintenance for Dirt And Gravel Roads Training upon which most of this manual is based. In addition to the contributors from the Center cited above, we want to acknowledge the Center staff for their support:

Barry E. Scheetz, Center Director
Tim Zeigler, Field Operations Specialist
Kathy Moir, Administrative Assistant

We also gratefully acknowledge the major contribution of the Pennsylvania State Conservation Commission, as the lead Commonwealth agency for Pennsylvania's Dirt and Gravel Roads Program which provides funding, administration and program guidance, with special thanks to:

Karl Brown, Executive Director
Michael J. Klimkos, Program Coordinator

Special recognition needs to be made to former State Senator Doyle Corman, who championed the Pennsylvania program through funding [Section 9106 of the Pennsylvania Motor Vehicle

Code] which established the 2-day training course and is responsible for its long-term continuation..

A special acknowledgement needs to be made to Woodrow "Woody" Colbert whose vision shaped the focus of the program to 'natural systems' and whose guidance kept the direction of the program focused on the local level where the program would be implemented. Without his efforts, the D&G program and this manual would never have existed.

In addition, although they are no longer part of the PA program, a special appreciation has to go to, Morris Perot, Kate Thompson, Denise Wardrup, Phil Dux, Joe Kisic, Shelly Stoffels and Eric Brown for their early work and shared experiences with the Pennsylvania Program.

We also have to thank PA Trout Unlimited and the efforts of Ed Bellis, Bud Byron and Wayne Kober, whose many members and chapters contributed untold hours of volunteer work who conducted the initial field surveys to establish the Dirt And Gravel Roads Program.

We are also grateful for the contributions and assistance from our Pennsylvania Department of Environmental Protection and our Pennsylvania Department of Conservation and Natural Resources, the Pennsylvania Game Commission, the Pennsylvania Fish and Boat Commission, the Pennsylvania Association of Township Supervisors, and the USDA National Resource Conservation Service.

We would like to acknowledge the National LTAP Program and all the state centers for continual sharing of information and technology , and particularly the Pennsylvania LTAP funded through PennDOT and the Federal Highway Administration and administered by the Pennsylvania Transportation Institute of Penn State University, which provided the basis for the original Pennsylvania dirt and gravel road training program. (Note: Both John Anderson and Alan Gesford were actively involved in the Pennsylvania LTAP, providing program administration, along with road maintenance training, training development, and technical assistance to Pennsylvania's municipalities.)

Our sincere thanks to the South Dakota Local Transportation Assistance Program (SD LTAP) (Ken Skorseth and Ali Selim, Ph.D., P.E), for allowing unlimited use of material from their Gravel Roads Maintenance and Design Manual., a product that has become an essential standard resource for gravel road maintenance personnel across the United States.

Our thanks to the national Rural Roads Group comprised of individuals from the US Environmental Protection Agency, Forest Service (US Department of Agriculture), Federal Highway Administration, Bureau of Indian Affairs (US Department of the Interior), Bureau of Land Management (US Department of the Interior), National Association of County Engineers (NACE), National Association of Counties, National Transportation Library, National Local Technology Assistance Program Association, the APWA LTAP Clearinghouse, and particularly to Tony Giancola, Executive Director of NACE, and associates, for their valuable reviews and critiques of this manual throughout the development task.

Special thanks goes to Albert Davenport, Davenport Communications, for editing services.

Also thanks to Penn State's Institute of State and Regional Affairs Director Michael Behney with special thanks to Stacey Faircloth for all her work in final electronic formatting.

Lastly, thanks to the County Conservation Districts, local municipal governments and various organizations and entities for allowing use of graphics and photos for the enhancement of this manual resource.

John A. Anderson, Ph.D.

Alan L. Gesford, P.E.

Barry E. Scheetz, Ph.D.

Table of Contents

Acknowledgements	i
Table of Contents	ii
Foreword.....	xii
1. Introduction.....	1-1
1.1. Manual Mission & Scope	1-1
1.1.1. The Mission	1-1
1.1.2. Scope.....	1-1
1.2. The Importance of Dirt and Gravel Roads	1-2
1.3. The Problem: Roads and the Environment.....	1-3
1.3.1. A Historical Perspective	1-3
1.3.2. The Connection.....	1-4
1.3.2.1.Factors Affecting Roads	1-4
1.3.2.2.Factors Affecting the Environment.....	1-4
1.3.2.3.The Road - Environment Relationship	1-5
1.3.3. Traditional Maintenance Practices.....	1-6
1.3.4. Combining Goals	1-7
1.3.5. Road Safety	1-7
1.4. The Manual: Philosophy, Objectives and Contents	1-7
1.4.1. The Manual Philosophy	1-7
1.4.2. The Manual Objectives	1-8
1.4.3. The Manual Contents	1-9
1.5. Essential Programs	1-10
Appendix 1. Case Study: The Pennsylvania Dirt and Gravel Roads Program.....	1-11
A1.1 Pennsylvania's Dirt and Gravel Roads	1-11
A1.2 Program Origin: A Problem Recognized	1-11
A1.3 Program Origin: A Problem Substantiated	1-12
A1.4 A Solution	1-13
A1.5 The Legislation	1-13
A1.6 Program Organization	1-13
A1.7 Program Goal	1-14
A1.8 Program Training	1-14
A1.9 Further Program Development.....	1-15
A1.10 Program Results	1-16

2. Geology, Rocks, and Soils	2-1
2.1. Introduction	2-1
2.2. Geology and Natural Forces	2-1
2.2.1. Geologic Time	2-2
2.2.2. Types of Binding Forces.....	2-2
2.2.3. Natural Physical Forces	2-3
2.3. Rocks	2-7
2.3.1. Rock Families	2-7
2.3.2. Geological Provinces	2-7
2.3.3. Rock as a Road Material	2-9
2.4. Soils	2-11
2.4.1. Soil Formation	2-11
2.4.2. Soil Particles	2-12
2.4.3. Soil Layers	2-13
2.4.4. Topsoil Versus Subsoil	2-15
2.5. Summary of Geology, Rocks, and Soils	2-16
 Appendix 2. Case Study: Pennsylvania's Geology	 2-17
A2.1 Central Lowland Province	2-18
A2.2 Appalachian Plateaus Province.....	2-18
A2.3 Ridge and Valley Province	2-19
A2.4 Blue Ridge Province	2-19
A2.5 New England Province.....	2-19
A2.6 Piedmont Province	2-20
A2.7 Atlantic Coastal Plain Province	2-20
A2.8 What Pennsylvania Has to Work With	2-20
 3. Water, Erosion, Drainage and Road Basics	 3-1
3.1. Introduction	3-1
3.2. Water and Erosion	3-1
3.2.1. Principles of Erosion.....	3-1
3.2.2. Accelerated Erosion	3-2
3.3. Water and the Importance of Road Drainage	3-2
3.3.1. The Importance of Drainage	3-2
3.3.2. Characteristics of Water.....	3-3
3.3.3. How Water Enters Our Roads.....	3-4
3.4. Road Drainage	3-5
3.4.1. Drainage Systems.....	3-5
3.4.2. Surface Drainage.....	3-5
3.4.2.1. Road Crown and Cross Slope	3-5
3.4.2.2. Road Shoulders	3-7
3.4.2.3. Road Structure (Cross Section).....	3-8
3.4.3. Subsurface Drainage	3-8

3.5. Road Materials.....	3-9
3.5.1. Quality Aggregates	3-9
3.5.1.1. Surface Aggregate versus Other Uses.....	3-10
3.5.1.2. Road Aggregate Specifications	3-11
3.5.1.3. Recycled Asphalt	3-12
3.5.2. Sampling and Testing Aggregates	3-13
3.5.3. Pit / Quarry Operations	3-14
3.6. Basic Road Maintenance Practices	3-16
3.6.1. Basic Techniques	3-16
3.6.1.1. Blading or Smoothing.....	3-17
3.6.1.2. Regrading or Reshaping	3-18
3.6.1.3. Adding New Material	3-19
3.6.2. Transitions	3-19
3.6.2.1. Road Intersections.....	3-19
3.6.2.2. Driveways	3-19
3.6.2.3. Curves	3-20
3.6.2.4. Railroad Crossings.....	3-20
3.6.2.5. Bridges	3-20
3.6.3. Frequency of Maintenance Operations	3-21
3.7. Summary	3-22
Appendix 3. Sample Aggregate Specifications	3-23
A3.1 Pennsylvania's Driving Surface Aggregate	3-23
A3.2 Illinois DOT Specifications	3-25
A3.3 Michigan DOT Specifications	3-27
A3.4 New York DOT Specifications	3-29
4. Basics of Natural Systems	4-1
4.1. Introduction.....	4-1
4.2. Ecology, Ecoregions and Ecosystems	4-2
4.3. The Stream Ecosystem (Community)	4-4
4.3.1. Introduction.....	4-4
4.3.2. Basics of Stream Ecology	4-4
4.3.2.1. Watersheds.....	4-4
4.3.2.2. Stream Systems.....	4-6
4.3.2.3. Hydrology	4-7
4.3.2.4. Water Quality.....	4-9
4.3.2.5. Stream Life.....	4-10
4.3.2.6. Stream Food Webs.....	4-10
4.3.2.7. Outside Inputs	4-11
4.3.2.8. Stream Habitat	4-12
4.3.3. Stream Management and Protection Goals.....	4-13
4.3.3.1. Indicator Species and Community Composition	4-13
4.3.3.2. Stream Evaluation	4-15

4.3.4. Impact of Erosion and Sediment on Streams	4-16
4.3.4.1. Suspended Sediment (Turbidity)	4-17
4.3.4.2. Sedimentation (Embeddedness).....	4-17
4.3.4.3. Attached Contaminants	4-18
4.3.5. Fish Constituency	4-18
4.3.6. Stream Ecosystem Summary	4-19
4.4. The Wetland Ecosystem (Community).....	4-19
4.4.1. Introduction.....	4-19
4.4.2. Definition of a Wetland	4-20
4.4.3. Wetland Basics	4-20
4.4.4. Wetland Management	4-21
4.4.4.1. Wetland Loss	4-22
4.4.4.2. Regulatory Protection	4-22
4.4.5. Wetland Benefits.....	4-23
4.4.5.1. Floodwater Storage	4-24
4.4.5.2. Bank Stabilization (Shoreline Protection)	4-25
4.4.5.3. Energy Dissipation.....	4-25
4.4.5.4. Sediment Trapping.....	4-25
4.4.5.5. Water Quality Improvement	4-26
4.4.5.6. Ecological Benefits	4-27
4.4.5.7. Economic and Social Benefits	4-28
4.4.6. Types of Wetlands	4-29
4.4.7. Wetlands and Road Maintenance.....	4-31
4.4.7.1. Recognizing Wetland Areas	4-31
4.4.7.2. Wetland Characteristics	4-31
4.4.7.3. Encountering Wetlands	4-35
4.4.7.4. Wetland Strategy.....	4-36
4.4.7.5. Working with Regulatory Agencies.....	4-37
4.4.8. Wetland Ecosystem Summary	4-37
4.5. The Upland/Forest Ecosystem (Community).....	4-38
4.5.1. Introduction	4-38
4.5.2. Plant Basics.....	4-38
4.5.2.1. Plant Growth & Photosynthesis	4-38
4.5.2.2. Vegetative Groupings	4-39
4.5.2.3. Plant Life Cycles.....	4-40
4.5.2.4. Root Structures.....	4-40
4.5.2.5. Plant Ecology	4-41
4.5.3. Understanding Trees	4-43
4.5.3.1. Tree Growth	4-43
4.5.3.2. Tree Injury	4-44
4.5.3.3. Tree Reaction to Injury	4-45
4.5.3.4. Proper Pruning	4-46
4.5.4. Plant Establishment and Succession	4-46
4.5.4.1. Colonizer Species.....	4-47
4.5.4.2. Intermediate and Climax Species.....	4-48
4.5.4.3. Significance of Plant Succession for Roadside Maintenance	4-49

4.5.5. The Importance of Plants	4-49
4.5.5.1. Ground Cover and Erosion Prevention	4-49
4.5.5.2. Air Conditioning	4-50
4.5.5.3. Air Purification	4-50
4.5.5.4. Water Purification.....	4-50
4.5.5.5. Aesthetics and Economics	4-51
4.5.6. Upland Ecosystem Summary	4-51
4.6. Summary of Natural Systems	4-51
 Appendix 4. Case Study: Pennsylvania's Ecology	 4-53
A4.1 Ecoregions and Geological Provinces.....	4-53
A4.2 Pennsylvania's Stream Ecosystems	4-53
A4.3 Pennsylvania's Wetland Ecosystems	4-55
A4.4 Pennsylvania's Upland Ecosystems.....	4-56
 5. Environmentally Sensitive Maintenance Practices: Roads and Road Drainage	 5-1
 5.1. Introduction.....	 5-1
5.2. Erosion Prevention and Sediment Control.....	5-1
5.2.1. Managing Your Erosion Prevention and Sediment Control Systems	5-2
5.2.2. Temporary and Permanent Erosion Prevention and Sediment Control Measures	5-2
5.2.3. Basic Temporary Practices	5-3
5.2.3.1. Straw Bale Barriers	5-3
5.2.3.2. Silt Fence Barrier	5-4
5.3. Environmentally Sensitive Maintenance Practices.....	5-6
5.3.1. Practices Related to Road Profile	5-6
5.3.1.1. Insloping	5-6
5.3.1.2. Outsloping.....	5-8
5.3.2. Practices Related to Roadside Ditches.....	5-9
5.3.2.1. To Ditch or Not To Ditch?.....	5-9
5.3.2.2. Ditch Shape	5-9
5.3.2.3. Ditch Slope.....	5-11
5.3.2.4. Alternative Ditch Cleaning Practices.....	5-12
5.3.2.5. Ditch Widening and Slope Flattening.....	5-12
5.3.2.6. Reuse of Topsoil and Vegetative Root Mats	5-12
5.3.2.7. Ditch / Channel Linings	5-13
5.3.2.8. Ditch Turnouts and Vegetative Filter Strips	5-16
5.3.3. Practices Related to Ditches and Road Profile	5-18
5.3.3.1. Broad Based Dips	5-18
5.3.3.2. Grade Breaks	5-20

5.3.4. Practices Related to Driveways	5-21
5.3.4.1. Proper Profile	5-21
5.3.4.2. Driveways Over Deep Ditches.....	5-22
5.3.4.3. Driveways Over Shallow Ditches.....	5-24
5.3.5. Practices Related to Culverts	5-25
5.3.5.1. Shallow Culvert Installations	5-27
5.3.5.2. Fords on Perennial Streams	5-29
5.3.5.3. Culvert End Structures.....	5-30
5.3.5.4. Aprons at Culvert Outlets	5-31
5.3.5.5. Through Drains	5-33
5.3.5.6. Large Culverts in Perennial Streams.....	5-34
5.3.6. Combination Practices	5-35
5.3.6.1. The Stream Saver System	5-35
5.3.6.2. Multiple Culverts	5-37
5.3.7. Major Reconstruction: Raising the Road.....	5-37
5.3.7.1. Raising the Entrenched Road.....	5-39
5.3.7.2. Raising the Road and Moving Away from a Stream	5-41
5.3.8. Practices Related to Bridges	5-41
5.3.8.1. The Stream Saver Bridge System	5-42
5.3.8.2. Gravel Bar Removal	5-43
5.3.8.3. Bridge Decks.....	5-43
5.4. Summary	5-44
Appendix 5. Worksites in Focus	5-45
A5-1. Worksite #1: Red Rose Road, Huntington County, PA.....	5-46
A5-2. Worksite #2: Horseshoe Road, Potter County, PA	5-54
A5-3. Worksite #3: Dutch Corner Road, Fulton County, PA.....	5-56
6. Environmentally sensitive Maintenance Practices: Roadsides and Streams	6-1
6.1. Introduction.....	6-1
6.2. Expectations of a Finished Product.....	6-2
6.3. Practices Related to Roadsides	6-3
6.3.1. Vegetation Management	6-3
6.3.2. Equipment and Methods	6-3
6.3.3. Roadside Clearing.....	6-4
6.3.3.1. Shading, Good or Bad?	6-5
6.3.3.2. Problems with Traditional Clearing Techniques	6-6
6.3.3.3. Alternative Techniques	6-8
6.3.3.4. Adjacent Residents and Off Right-of-Way Work.....	6-9
6.3.3.5. Advantages of Using the Forest System	6-10
6.3.3.6. A Common Pitfall in Tree Removal	6-10
6.3.3.7. Tree Leaves.....	6-11
6.3.4. Using Other Plants for the Roadside.....	6-12

6.3.5. Clearing Stream Banks at Cross Pipes.....	6-14
6.3.5.1. Common Practice and Associated Problems	6-14
6.3.5.2. Alternative Practices	6-15
6.3.5.3. Benefits of a New Approach	6-15
6.4. Practices Related to Road and Stream Banks.....	6-16
6.4.1. Initial Site Visit.....	6-17
6.4.2. Proven Techniques for Banks	6-21
6.4.2.1. Diversion Swales	6-21
6.4.2.2. Slope Geometry	6-22
6.4.2.3. Benching	6-23
6.4.2.4. Seeding and Mulching	6-24
6.4.3. Bioengineering Techniques	6-26
6.4.3.1. Live Stakes.....	6-27
6.4.3.2. Live Fascines	6-29
6.5. Summary	6-30
Appendix 6.....	6-32
Appendix 6A. Soil Identification in the Field	6-33
Appendix 6B. Additional Worksite in Focus.....	6-35
A6B-1 Worksite #4: Fall Brook Road, Tioga County, PA	6-36

7. Environmentally Sensitive Maintenance Practices: Additional Maintenance Techniques 7-1

7.1. Introduction.....	7-1
7.2. Dust Control	7-1
7.2.1. What is Dust? and Where Does It Come From?.....	7-2
7.2.2. The Necessity of Dust Control.....	7-2
7.2.3. Benefits of a Dust Control Program.....	7-3
7.2.4. Dust Control Options	7-4
7.2.5. Evaluation of Dust Suppressant Materials.....	7-5
7.2.6. Common Dust Suppressants	7-6
7.2.6.1. Water.....	7-6
7.2.6.2. Sodium Chloride	7-7
7.2.6.3. Calcium and Magnesium Chlorides.....	7-7
7.2.6.4. Brines	7-7
7.2.6.5. Lignin Derivatives	7-7
7.2.6.6. Asphalt Emulsions and Cutbacks.....	7-8
7.2.6.7. Resins and Other Materials.....	7-9
7.2.7. Use and Application of Dust Suppressants	7-9
7.2.7.1. Environmentally Sensitive Materials.....	7-10
7.2.7.2. Application Process	7-10
7.3. Road Stabilization.....	7-11
7.3.1. What is Road Stabilization?.....	7-11
7.3.2. Advantages of Stabilization	7-11
7.3.3. Stabilization Additives.....	7-12

7.3.4. The Stabilization Process	7-12
7.4. Geosynthetics	7-15
7.4.1. Why Use Geosynthetics?	7-16
7.4.2. Functions and Applications.....	7-16
7.4.3. Geotextile Fabrics	7-16
7.4.4. Geosynthetic Applications in Road Maintenance	7-17
7.4.4.1. Drainage/Infiltration Fabrics.....	7-17
7.4.4.2. Prefabricated Subdrains	7-19
7.4.4.3. Subdrain Outlets.....	7-19
7.4.4.4. Erosion and Sediment Control.....	7-19
7.4.4.5. Embankment Soil Reinforcement.....	7-21
7.4.4.6. Separation Fabrics.....	7-21
7.4.4.7. French Mattress.....	7-24
7.4.4.8. Geocells & Geoweb.....	7-25
7.4.4.8.1. Road Stabilization.....	7-25
7.4.4.8.2. Retaining Walls.....	7-26
7.4.4.8.3. Low Water Road Crossing.....	7-26
7.4.4.8.4. Road Stream Ford Crossing.....	7-27
7.4.4.9. Prefabricated Geosynthetic Pipe Endwalls	7-28
7.5. Summary	7-29
Appendix 7	7-31
Appendix 7A. Pennsylvania's Testing and Approval Program for Dust Suppressants and Road Stabilizers.	7-31
Appendix 7B. Worksites in Focus	7-33
A7B-1 Worksite #1: Miltenberger Road, Adams County, PA	7-34
A7B-2. Worksite #2: Powdermill Nature Reserve, Westmoreland County, PA	7-36
A7B-3. Worksite #3: Hell Hollow Road, Monroe County, PA	7-38
Glossary	8-1
References	9-1
Technical Information Sheets	10-1
ESMP-01 Insloping	10-2
ESMP-02 Outsloping	10-4
ESMP-03 Ditch Turnouts & Vegetative Filter Strips	10-6
ESMP-04 Broad Based Dips	10-9
ESMP-05 Grade Breaks	10-12
ESMP-06 Driveways	10-15
ESMP-07 Culvert End Structures	10-18
ESMP-08 Culvert Aprons	10-21
ESMP-09 Shallow Culvert Installations	10-23
ESMP-10 Through Drains	10-26
ESMP-11 Stream Saver System	10-28

ESMP-12 Raising the Entrenched Road	10-31
ESMP-13 Slope Geometry, Benching and Diversion Swales	10-35
ESMP-14 Roadside Trees – Using the Forest System to Reduce Maintenance	10-39
ESMP-15 Road Separation Fabrics	10-44

Foreword

This manual was written for Road Maintenance Personnel.

To use this manual, do the following two things:

1. Review the underlying basis, mission and major objectives for this manual:

Basis of the Manual: The following facts are the driving force behind development of this manual:

1. Over 1.6 million miles of dirt and gravel roads exist within the United States, and they provide a vital service as part of the nation's transportation system.
2. Dirt and gravel roads will remain important and significant in mileage and use into the future.
3. The depositing of unwanted sediments into our streams and waterways represents one of the largest pollution problems in North America, and improperly maintained dirt and gravel roads are major contributors to this problem.

The Manual's Mission:

The mission of this manual is to address this pollution problem affecting our streams and stemming from our dirt and gravel roads in the form of erosion, sediment and dust.

Major Objectives to Accomplish the Mission:

1. Provide users with an understanding that *our road system is part of our overall environment, that a vital connection exists between the two, and that this connection needs to be considered in whatever actions we take in regards to constructing and maintaining our road system.* In doing so, we will be able to preserve our environment and more effectively and efficiently prolong the life of our transportation system.
2. Give users a 'tool box' full of environmentally sensitive maintenance 'tools' or practices that support both good roads and a good environment by offering a variety of simple, practical environmentally sensitive maintenance practices and by providing a means for using these practices in routine road maintenance.

The practices presented in this manual are inclined toward use for dirt and gravel roads in forested areas. The user may find, however, that many of the concepts and practices could prove applicable in various types of environments, and possibly require only minor research and development efforts.

2. Look at the Chapter Titles to determine how to effectively use the information presented:

Chapter:

- 1. Introduction**
- 2. Geology, Rocks and Soils**
- 3. Water, Erosion, Drainage and Road Basics**
- 4. Basics of Natural Systems**
- 5. Environmentally Sensitive Maintenance Practices: Roads and Road Drainage**
- 6. Environmentally Sensitive Maintenance Practices: Roadsides and Streams**
- 7. Environmentally Sensitive Maintenance Practices: Additional Techniques**

By looking at the Chapter titles, we see that the maintenance “guts” of this manual are contained in Chapters 5, 6, and 7 on “Environmentally Sensitive Maintenance Practices”. These are the chapters that you may want to read all the way through and then use this information with the accompanying “Technical Information Sheets” in implementing these practices for better roads and a better environment.

If this is all you do, however, you will not have a full understanding of why you are doing a particular practice a particular way or how these practices really work to better the road and the environment. This path is the traditional philosophy of telling someone what to do without any explanation of why it works or the reasons or factors upon which the practice is based. Without a full understanding of “why and how it works,” the wrong reasoning for doing any work may prevail - “this is the way we always did it.” On the other hand, if we fully understand the “why and how it works,” we become confident in doing it right and can use this knowledge to actually improve upon the practice and its use in maintaining our roads.

This is where Chapters 1, 2, 3, and 4 become most important. These chapters give background information that enables an understanding of “how and why it works.” We feel that it is important for road personnel to have “the whole story” or all the information behind the practices. This will enable them to implement the proper practice when needed or desired. Road personnel should know why and what they are doing, and why and how it benefits both the roads and the environment.